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# APPLICATION
# FOR
# UNITED STATES
# LETTERS PATENT

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For: SATELLITE CARRIER MEASUREMENT SYSTEM AND METHOD
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# SATELLITE CARRIER MEASUREMENT SYSTEM AND METHOD

## BACKGROUND OF THE INVENTION

1. Field of the Invention.

This invention generally relates to monitoring the quality of satellite communications, and more particularly to a system and method for measuring satellite downline EIRP (Effective Isotropic Radiated Power) power of modulated radio frequency carrier signals.

2. Description of the Related Art.

Satellite systems communicate information by establishing uplinks and downlinks between two earth stations on predetermined carrier frequencies. The earth stations may be fixed or mobile and the information may be voice, video, data, or a combination thereof.

In satellite subscriber systems, customers are usually assigned one or more carrier frequencies depending on available capacity. These carrier frequencies are usually contractually agreed to, along with performance parameters including power level. Periodically, system subscribers monitor the EIRP level of their transmissions by requesting such information from a technical operations center of the satellite communications provider. The EIRP level must be acceptable under the terms of the contract or steps must be taken to correct the quality of transmissions.

Conventional methods for measuring EIRP power involve a large number of steps, most of which are manually performed by a technician. These methods first require the technician to access a computer system (Transponder View) containing customer information. From this system, the technician would write down notes indicating the location on the transponder as well as other operational information. The technician would then manually input other information (e.g., frequency, span, reference level) into a spectrum analyzer using a panel keypad on the front of the instrument. Using the spectrum analyzer, the technician measures the bandwidth of a modulated RF carrier signal received from a satellite downlink (typically, at the 3 db points) and then the power level of the carrier signal as compared with a reference carrier, usually 10 dbw in strength.

After taking these measurements, the technician inputs them into a Visual Basic program (known as "SCPC Power") to achieve a calculated power reading of the modulated data carrier. The measured and calculated power readings are then compared to the contracted information from Transponder View computer system. From this comparison, problems associated with the satellite downlink are determined and subsequently addressed. From this comparison, the technician also determines if the customer's carrier is operating at the proper level. If the customer's carrier is operating at an excessive level in a power-shared transponder, other carriers handled by the transponder could be compressed or otherwise degraded. The customer may also experience degraded service because the carrier is operating at too low of a power level.

There are at least three drawbacks to the conventional methods discussed above. First, these methods require a large number of steps and many of them are manually performed. This makes the measurement process time inefficient, and the substantial involvement of a technician increases costs and introduces the possibility of human error. Second, the conventional methods require the use of separate hardware components, each of which must be manually operated by the technician. This further increases costs and inefficiencies. Third, conventional methods require the use of separate computer programs implemented at different stages of the measurement-taking process. For example, one program is embodied within the Transponder View computer system which a technician must initially access to obtain customer information. Another program is the Visual Basic program which the technician uses to obtain calculated power measurement readings. Using separate programs of this type further increases costs and inefficiencies. Also, the presence of a technician is a necessity because none of these programs "talk" to one another.

From the foregoing discussion, it is apparent that a need exists for a method of the measuring power of a satellite downlink carrier signal which is faster and more efficient than conventional methods.

## SUMMARY OF THE INVENTION

It is a first object of the present invention to provide a method for measuring the power of a satellite downlink carrier signal which is faster and more efficient than conventional methods.

It is another object of the present invention to achieve the first object by providing a computer-implemented method which automatically performs all the steps necessary to measure power of the carrier signal, thereby substantially or altogether eliminating the role of the technician in the measurement-taking process. As a result, the method of the present invention advantageously reduces costs in terms of manpower and the need to use separate disjoint computer programs. Also, by automating the method steps preferably using a single comprehensive computer program, a quicker and more reliable response time may be realized.

The foregoing and other objects of the invention are achieved by providing a method which automatically takes satellite carrier power measurements, which method may advantageously replace conventional methods that are largely manual performed and disjoint in terms of their processing steps and hardware requirements. Preferably, the method is embodied within a single computer program implemented by a processor in a Technical Operations Center (TOC) maintained or managed on behalf of a satellite company.

In accordance with a preferred embodiment, the method of the present invention measures EIRP power of a modulated satellite downlink RF carrier by identifying a frequency corresponding to the carrier signal, measuring a power level and bandwidth of the carrier signal at said frequency, determining a level of a reference carrier signal, and calculating an EIRP power value for the carrier signal based on the measured power level and bandwidth and the level of said reference carrier signal. Advantageously, any one or more of the measuring, determining, and

calculating steps are automatically performed under control of a computer program. This substantially reduces human involvement and therefore the costs associated therewith. At the same time, the power-measuring process is made faster and more efficient. To provide improved customer service, the calculated EIRP power value may be automatically displayed on a customer service terminal.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of a preferred embodiment of the system of the present invention for automatically measuring power in satellite downlink carrier signals.

Fig. 2 is a flow diagram showing steps included in a preferred embodiment of the method of the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Fig. 1, a preferred embodiment of the system of the present invention is preferably implemented in a Technical Operations Center (TOC) 1 maintained or managed on behalf of a satellite communications company. The TOC includes a central processor 5, one or more user terminals 10, a spectrum analyzer 15, a memory unit 20, a database 25, and a link 30 connected to a satellite receiver 35 tuned to receive, for example, video (digital or analog) and/or audio signals. While the processor is shown as being physically located at the TOC, those skilled in the art can appreciate that the processor, the memory unit, and/or database may

alternatively be connected to the TOC through a network. Further, while not specifically shown it is understood that the TOC is connected to a telephone system for receiving calls from customers relating to carrier power measurements.

The central processor executes a computer program used to implement the method of the present invention, as well as other programs/sub-routines the program may access to perform the steps of the method. The computer program includes code for automatically gaining access to and then controlling the spectrum analyzer, the satellite receiver, and any other hardware unit needed to measure power of a modulated carrier signal in accordance with the invention.

The program itself may be accessed through a "cockpit program" which resides on and is initiated by a representative at one of the user terminals in the TOC. Preferably, the cockpit program is a program that is used to choose the appropriate satellite, transponder, and polarization(vertical or horizontal). By first choosing the satellite and transponder (polarization is automatically chosen depending upon the satellite and transponder selected), the technician can then input the desired frequency of the carrier that needs to be measured for downlink EIRP.

The spectrum analyzer may be a conventional type which is configured or modified to receive control signals from the central processor. When instructed, the spectrum analyzer measures the power level and bandwidth of the modulated RF carrier signals directly from the satellite. The carrier bandwidth can be measured by adjusting the filtering (e.g., video bandwidth and resolution bandwidth) and the span of the carrier observed. The analyzer also automatically measures the power level of a reference carrier. The reference carrier may be automatically selected by the

program based, for example, on the satellite and/or transponder selected. The reference carrier represents a fixed CW (continuous wave) carrier at a power level of 10 dbw at a specific frequency. The bandwidth and power-level measurements are automatically sent to the central processor for use in computing EIRP measurements of the carrier signal.

The database stores customer information which includes customer carrier frequency, transponder location, and other operational information such as the bandwidth of the carrier, that will be compared with the measured bandwidth, and the downlink EIRP at specific locations. These specific locations are usually the "Technical Operations Centers."

The EIRP power is the maximum power each customer in the system is allotted. Knowing the EIRP power in an integrated satellite system is advantageous in a number of respects. Perhaps most importantly, if EIRP power is significantly exceeded for any one customer, then other customers' carriers in the transponder may be degraded because power may be taken away from them. By measuring the downlink EIRP, each customer may be held to his contractual agreement. At the same, safeguards are ensured with respect to the other customers in the shared transponder. When the power level is exceeded, the customer would be expected to make necessary adjustments to establish the correct level.

Referring to Fig. 2, a preferred embodiment of the method of the present invention for automatically measuring EIRP power begins when a customer calls the TOC in order to request receipt of downlink EIRP measurements of a carrier signal. (Block 100). The call may be taken by a representative at one of the user terminals.

In response to the customer request, the representative initiates a computer program which automatically implements the steps of the method of the present invention for obtaining EIRP measurements. Initiation of the computer program may be made through activation of the cockpit program. As previously discussed, the cockpit program is a program used to select the appropriate satellite, transponder, and polarization of the carrier that needs to be observed or measured. Once this is established, the downlink EIRP program of the invention may be activated to automatically measure the power level of the customers' carrier.

Once initiated, the cockpit program calls a satellite and an appropriate transponder corresponding to the carrier signal based on, for example, information stored in the database. (Block 105). In accordance with a preferred embodiment of the method of the present invention, the cockpit program is only used to select the satellite and transponder and consequently the polarization for the carrier. The present invention may be a sub-routine that is used in conjunction with (e.g., is called by) the cockpit program.

Next, the program sends control information to the spectrum analyzer in order to automatically adjust the analyzer to the bandwidth (e.g., video bandwidth and/or resolution bandwidth), span, and carrier frequency identified as corresponding to the customer in the retrieved database information. (Block 110). The video bandwidth may be used for filtering the signal to an acceptable view. Practically speaking, this bandwidth 'cleans up' the carrier, and in this regard the program may be used to measure the downlink EIRP of SCPC (single carrier per channel) signals.

After these adjustments are made, the spectrum analyzer automatically measures the level and bandwidth of the customer's carrier signals within the specified bandwidth. (Block 115). This step may be performed by instructing the analyzer to automatically activate a delta marker, adjusting this marker to the 3 db point on one side of the carrier, and then having the analyzer store the carrier in a trace "A." The marker may be established at the peak amplitude of the carrier, after which the delta marker function is then activated. The analyzer may also activate a trace "B" and dial in the frequency of the 10 dbw reference carrier, which is then placed directly in relation to the delta marker on the customer's carrier. The spectrum analyzer is then instructed by the program to read and record the 3 db bandwidth and amplitude of the customer's carrier. The spectrum analyzer also measures the level of the reference carrier. This information along with the bandwidth and amplitude information is sent back to the central processor.

Next, the program automatically activates the downlink EIRP program stored in the memory unit and then inputs the 3 db bandwidth, amplitude, and reference carrier level information from the spectrum analyzer into the EIRP program. (Block 120). The program then automatically calculates the EIRP power of the customer's carrier signal in accordance with steps that include applying a modulated-data-carrier formula which computes a correction factor(CF) that is related to the power of an unmodulated carrier. The inputs to this formula are the measured bandwidth and the resolution bandwidth in which it is measured.

The modulated-data-carrier formula may be expressed as: CF = 10*Log (Measured Bandwidth/Resolution Bandwidth). As indicated above, the resolution bandwidth is a selected value which adequately displays the true signal. An example would be 30 kHz, however those skilled in the art can appreciate that other values may be used. In accordance with the invention, the program discussed herein contains code which automatically adjusts the spectrum analyzer to a desired resolution bandwidth. Once calculated, the correction factor is added to the difference between the amplitude of the reference carrier and the amplitude of the modulated carrier to compute the downlink EIRP.

The steps performed by the present invention to automatically calculate EIRP power may be summarized as follows:

1. Save carrier in Register #1.
2. Perform maximum hold on the carrier to smooth out trace.
3. Save carrier in Register #2.
4. Perform a peak search on the carrier, and determine the maximum amplitude.
5. Activate a delta marker on a peak amplitude and move marker 3db below peak on one side.
6. Move marker to other side of peak amplitude at 3db down.
7. Output 3db bandwidth.
8. Calculate correction factor as indicated above.
9. Recall Register #2.

10. Perform a peak search on the carrier, store in Trace A, and activate the delta marker.

11. Clear/Write Trace B.

12. Call the reference carrier for that transponder.

13. Output the difference between reference carrier amplitude and customers' modulated carrier amplitude.

14. Add the correction factor and marker amplitude difference to compute downlink EIRP.

Once the EIRP power level for the customer's carrier signal has been calculated, it is displayed at one of the user terminals under direction of the program via the central processor. (Block 125). Preferably, Transponder View and SAP data programs are used as the source of the contracted level information used in the comparison described above.

Finally, the EIRP power measurements and their deviation from the contracted assigned power is conveyed to the customer by the representative at the user terminal. (Block 130). The information may be conveyed over the phone, electronically via an e-mail, or any other form of conventional communication.

Other modifications and variations to the invention will be apparent to those skilled in the art from the foregoing disclosure. Thus, while only certain embodiments of the invention have been specifically described herein, it will be apparent that numerous modifications may be made thereto without departing from the spirit and scope of the invention.